placement at a later time is used. A mixture of particulate corticocancellous bone and porous HA is the author's material of choice for grafting.

The mixture of cancellous bone and porous HA has proven to be a very predictable graft material in the severely atrophic maxilla, just as it has been for the atrophic mandible. After adequate time for graft healing, preparation for osseointegrated fixtures is easily accomplished by means of the porous HA–cancellous bone mixture.

The three approaches described have all resulted in success. The use of the modified denture technique has become the method of choice whenever the patient's esthetic demands require it.

REFERENCES

1. Breine U, Brånemark P-I: Reconstruction of alveolar jawbone: An experimental and clinical study of immediate and preformed autologous bone grafts in combination with osseointegrated implants. Scand J Plast Reconstr Surg 14:23–48, 1980.
2. Keller EE, VanRoekel NB, Desjardins RP, Tolman DE: Prosthetic surgical reconstruction of the severely resorbed maxilla with iliac bone grafting and tissue integrated prosthesis. Int J Oral Maxillofac Implants 3:155–165, 1987.
3. Sailer HF: A new method for inserting endosseous implants in totally atrophied maxillae. J Craniomaxillofac Surg 17:299–305, 1989.
4. Reitzik M: Bone grafting for implant placement. Presentation to Osseointegration Study Club of Southern California, January, 1990.
5. Kent JN, Quinn JH, Zide MF, et al: Alveolar ridge augmentation using non-resorbable hydroxylapatite with or without autogenous cancellous bone. J Oral Maxillofac Surg 41:629–642, 1983.
6. Davis WH, Davis CL, Delo R, et al: Surgical management of soft tissue problems. *In* Fonseca RJ, Davis WH (eds): Reconstructive Preprosthetic Oral and Maxillofacial Surgery. Philadelphia, WB Saunders, 1986.
7. Cobb CM, Eick JD, Barker BF, et al: Restoration of mandibular continuity defects using combinations of hydroxylapatite and autogenous bone—microscopic observations. J Oral Maxillofac Surg 48:268–275, 1990.
8. Adell R, Sekholm U, Rockler B, Brånemark P-I: A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 10:387–416, 1981.
9. Davis WH, Hochwald DA, Daly B, Owen WF: Reconstruction of the severely resorbed mandible. J Prosthet Dent 64:583–588, 1990.
10. Hochwald DA, Davis WH, Marshall MW: Reconstruction of the severely resorbed maxilla with autogenous ilium, porous HA and Brånemark implants. 4th International Congress on Preprosthetic Surgery, Palm Springs, CA, 1991.
11. Boyne PJ: Regeneration of alveolar bone beneath cellulose acetate filter implants [abstract]. J Dent Res 43(Suppl):827, 1964.
12. Tatum H Jr: Maxillary sinus and implant reconstruction. Dent Clin North Am 30:107–119, 1986.
13. Kent JN, Block MS: Simultaneous maxillary sinus floor bone grafting and placement of hydroxylapatite-coated implants. J Oral Maxillofac Surg 47:238–242, 1989.
14. Smiler DG, Holmes RE: Sinus lift procedure using porous hydroxylapatite—a preliminary clinical report. J Oral Implantol 13:239–253, 1987.

PART 3: THE PRINCIPLE OF REMOVAL OF THE SINUS FLOOR MUCOSA FOR NEW PREPROSTHETIC RECONSTRUCTION METHODS (SINUS INLAY METHODS)

Hermann Sailer, D.D.S., M.D.

Conventional reconstructive operations in preprosthetic surgery of the upper jaw, such as rebuilding the alveolar ridge using rib grafts[1] or Le Fort I osteotomies of the edentulous maxilla,[2,3] have been widely abandoned in our department in favor of new methods combining bony reconstruction and simultaneous placement of osseointegrated implants.[4,5] For these methods the author has developed the principle of removal of the mucosal lining from the floor of the maxillary sinus followed by a bone inlay (sinus inlay method). Two procedures that use this principle are described below.

METHOD 1

The Le Fort I operation uses sinus and nasal bone inlay and simultaneous placement of osseointegrated implants.

Indications

1. Atrophy of maxilla. The edentulous severely atrophic maxilla with missing alveolar ridges and pseudoprognathism or skeletal Class III relation. Usually the residual alveolar ridge is so thin that it coincides with the floor of the sinus, so that neither a conventional denture nor an implant-supported denture is feasible. This status is an indication for Method 1 reconstruction.
2. Esthetic improvement. Another frequent indication is the reconstitution of the former facial height and the midfacial projection; the esthetic component of the procedure with a rejuvenating effect is conspicuous.
3. Overexpansion (hyperpneumatization) of the sinus. A further indication is the overexpansion of the maxillary sinus into the edentulous alveolus, often in combination with anterior alveolar resorption caused by an anterior mandibular residual dentition. The clinical aspect of this quite common condition is a flabby ridge in the front and normal-looking alveolar ridges in the posterior parts of the maxilla with well-developed tuberosities. Because of the hyperpneumatization and overexpansion of the maxillary sinus, no alveolar bone remains for the placement of implants.
4. Postsurgical conditions. A special indication is the severely damaged maxilla after loss of subperiosteal and other implants, sometimes combined with chronic sinusitis and persistent oroantral and oronasal fistulae.

Surgical Procedure

1. Incision. The incision line is made along the crest of the ridges and through the tuberosities. In the midline a vertical incision is usually necessary to facilitate circular degloving of the buccal and labial aspects of the maxilla. In order to make the placement of

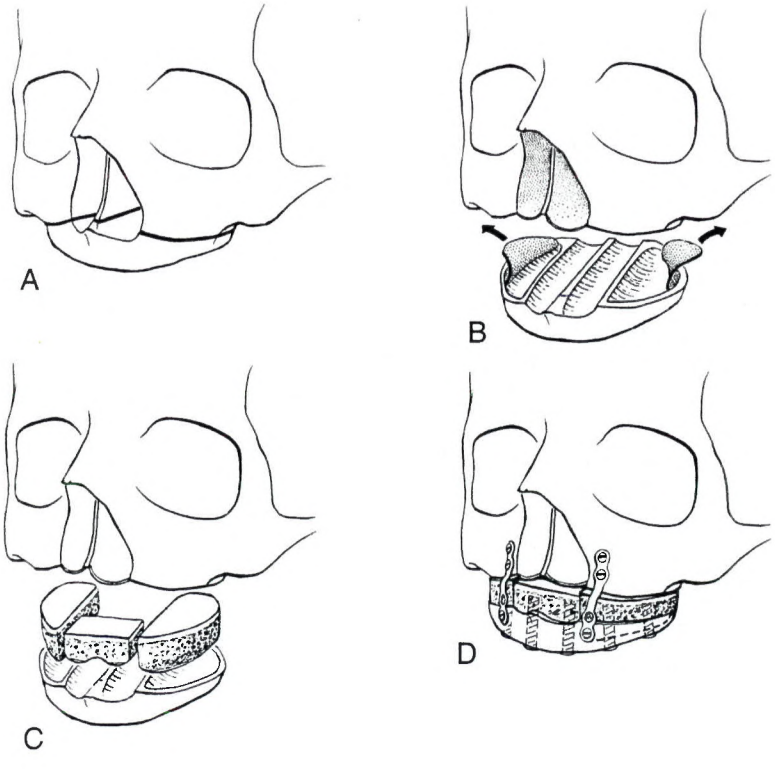


Figure 15–165. Le Fort I operation with removal of the mucosal lining of the sinus floor, bone inlays, and placement of screw implants: Following the Le Fort I osteotomy and careful mobilization of the atrophic maxilla *(A)*, the mucosa is removed from the floor of the maxillary sinus *(B)*, whereas the nasal mucosa is preserved; bone grafts are adapted to the form of the sinus floor *(C)* and fixed by titanium screw implants *(D)*.

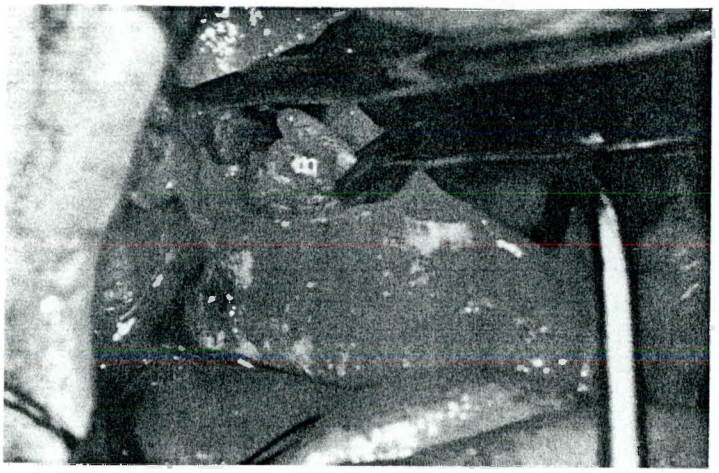


Figure 15–166. Intraoperative view showing the removal of the mucosa (m) from the floor of the sinus: A clamp is holding the mucosa; a hook is placed into the piriform aperture, pulling the mobilized maxilla downward.

fixation stitches for a submucosal vestibuloplasty easier, it is recommended not to mobilize the mucoperiosteum in the canine fossa.

2. Precautions during Le Fort I osteotomy. A routine Le Fort I osteotomy (Fig. 15–165*A*) is performed after careful elevation of the mucoperiosteum from the piriform aperture and the nasal meatus. The nasal septum is osteotomized along the palate. The separation of the tuberosities from the pterygoids has to be done "with love" without fracturing the thin tuberosities.

Downfracturing the maxilla in the usual way is contraindicated because of the risk of fracturing. Instead, the mobilization occurs carefully by means of broad chisels positioned into the osteotomies along the lateral nasal walls and by slight downward pressing of the whole maxilla parallel with the horizontal plane. Forward movement is performed gently with our mobilization hooks.

3. Removal of the mucosal lining. The most important step of the method is the total removal of the mucosal lining from the floor of the maxillary sinus, that is, from the mobilized part of the maxilla, using Freer instruments (Figs. 15–165*B* and 15–166). Usually there is slight bleeding from the denuded surface. The mucosal lining of the superior part of the maxillary sinus remains untouched.

4. Nasal mucosal lining. The nasal mucoperiosteum, if damaged, is repaired by a continuous running suture of chromic catgut, everting the edges to the nasal side.

5. The bone grafts. Autologous iliac bone grafts (or other autologous bone such as calvarium) are inlayed into the most anterior part of the piriform aperture and into the sinus floor (Fig. 15–165*C*). In order to facilitate the shaping of the bone grafts, lead templates, easily cut with scissors, are adapted to the size of the sinus floor. The height of the inlayed bone, the direction of the dental implants within these bones, and the amount of the downward movement of the maxilla determine the length of the implants. Usually we are able to insert implants of 15 to 20 mm in length. It is important that the bone blocks in the piriform aperture are not higher than the amount of downward positioning of the maxilla in the anterior part; otherwise, nasal obstruction is possible.

We prefer to use bicortical iliac bone grafts, but monocortical ones also can be used, especially if substantial residual alveolar bone is present. Usually the cortex is placed upwards facing the nasal or sinus cavity. In some cases, however, a vertical position of the cortex can be advantageous. The implants are inserted so that they just penetrate the cranial surface of the bone graft.

If calvarial bone is used, two or three pieces have to be placed on top of each other. The risk of dislocation of these pieces during placement of the implants is greater than when using one piece of bone! Moreover, in calvarial bone grafts, self-tapping implants cannot be used, whereas this is possible in iliac bone.

6. Fixation of bone during surgery. It is very important that the bone blocks are fixed firmly during the insertion of the dental implants. For this purpose our specially designed maxillary bone holder is used (see Fig. 15–172*B*). When the bone holder is removed, the

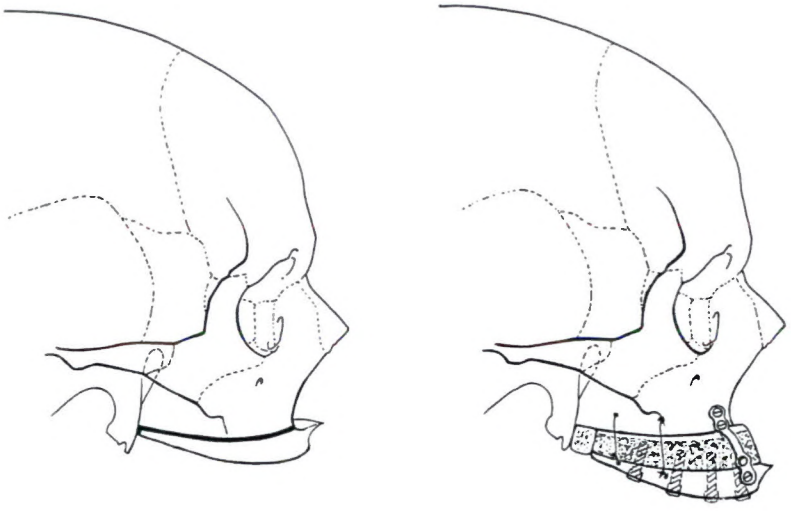


Figure 15–167. The maxilla is moved forward and especially downward in the anterior part *(right)*, in order to compensate for the loss of facial height; the later lip/incisor relation has to be respected.

bone blocks are held in place by the titanium implants alone. No further fixation of the bone graft is necessary. This is usually done in the piriform aperture before performing the sinus inlay. Usually 6 to 12 implants are placed depending on the preoperative planning. In rare cases only 4 implants have been inserted.

7. By means of our maxillary bone holder the maxilla is placed into the desired position—usually forward and downward—and fixed there with miniplates or wires (Figs. 15–165*D* and 15–167).

8. The abutment operation is performed 4 to 6 months later, and the patient is usually provided with facultatively removable bridges (Fig. 15–168).

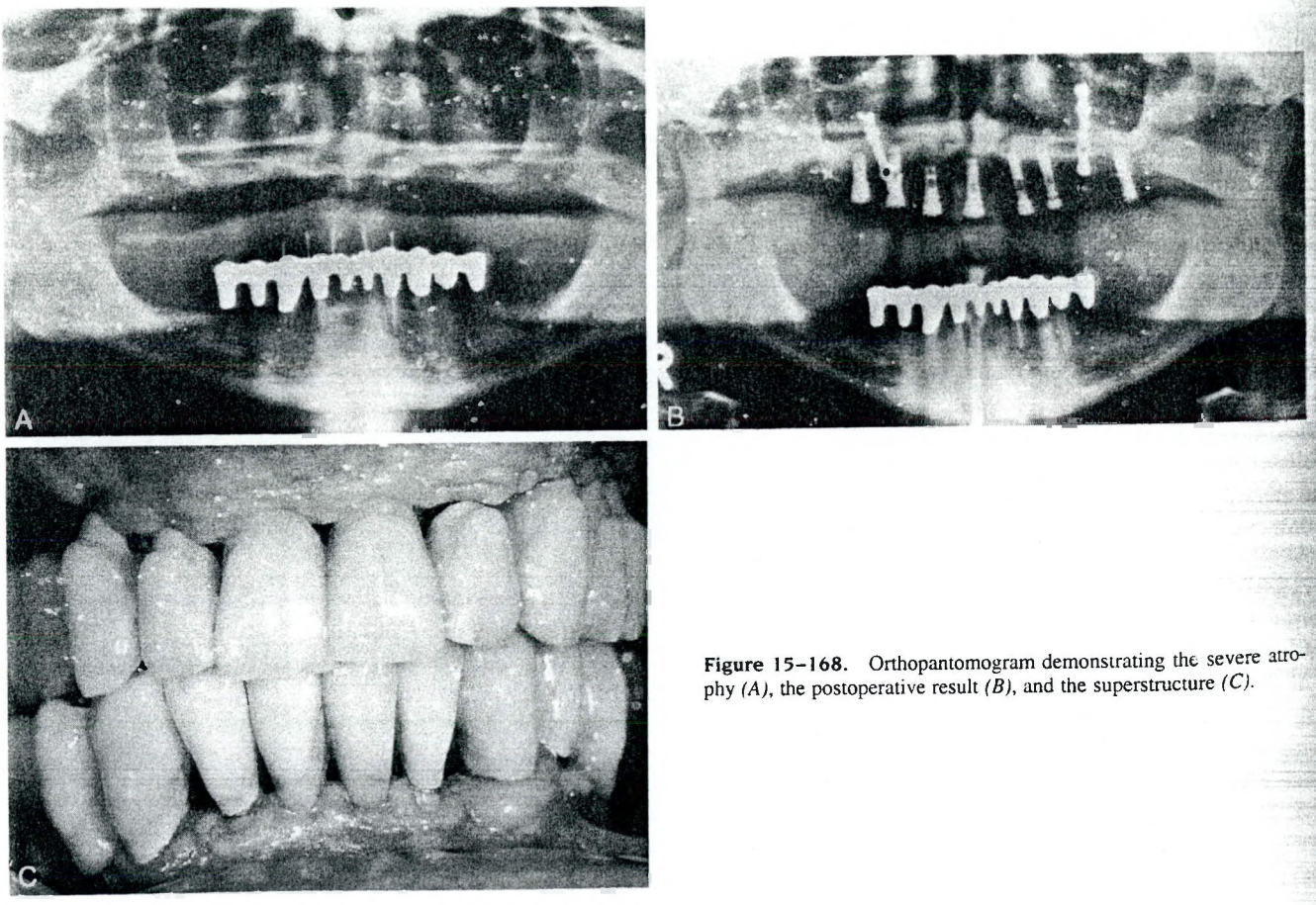


Figure 15–168. Orthopantomogram demonstrating the severe atrophy *(A)*, the postoperative result *(B)*, and the superstructure *(C)*.

METHOD 2

Method 2 is the lateral approach for sinus inlay grafting and simultaneous placement of osseointegrated implants following removal of the mucosal lining from the sinus floor.

Indications

This procedure is indicated for the maxilla with an anterior residual dentition which is severely resorbed in its unilateral or bilateral edentulous parts. Similar to the method described above (indication 3), the nonatrophic alveolus with overexpansion of the maxillary sinus is an excellent indication for this method.

Surgical Procedure

1. The incision line runs on the crest of the alveolus to the most posterior tooth, where a vestibular extension is performed.
2. The canine fossa is degloved to the piriform aperture and with a fine oscillating saw a large window is cut (Fig. 15–169*A*). The bone lid with the adherent mucosa is stored in Ringer's solution.
3. The mucosal lining of the sinus floor is elevated with a Freer instrument and cut off (Figs. 15–169*B* and 15–170).

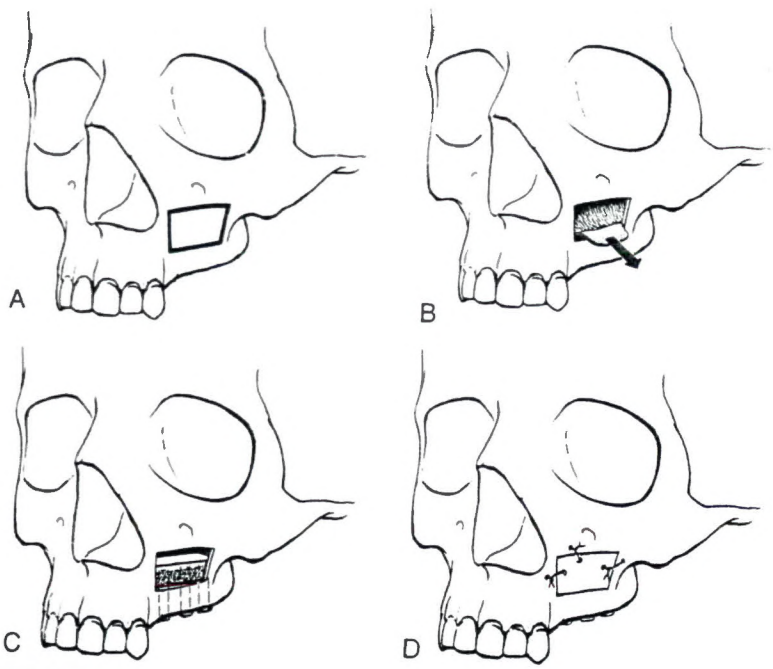


Figure 15–169. Sinus bone inlay method with removal of the mucosa from the sinus floor and simultaneous placement of implants: A large fenestration of the sinus is performed using an oscillating saw *(A)*; the mucosa is carefully elevated from the floor of the sinus only *(B)*; a bone block is adapted *(C)* and immediately fixed by titanium screw implants; the bony lid is replaced and fixed by wires or sutures *(D)*.



Figure 15–170. Intraoperative photograph depicting the lifting of the mucosal lining with a clamp before being cut off.

4. An autologous bone block taken from the ilium (Fig. 15–171), the chin area, or the mandibular ramus or elsewhere is shaped and placed into the denuded floor (Fig. 15–172*A*). It is fixed by means of our fixation clamps (Fig. 15–172*B*), and the titanium implants are inserted through the alveolar bone into the bone grafts (Figs. 15–169*C* and 15–172*C*).

5. The bone lid is placed into its original position and fixed by stitches or wires (Figs. 15–169*D* and 15–172*D*). Fixation with plates is also possible.

6. Mobilization of the oral mucosa is performed by horizontal periosteal incisions, and a continuous running suture with nonresorbable material is used for wound closure.

7. The abutment procedure is performed 4 to 6 months later (Fig. 15–173).

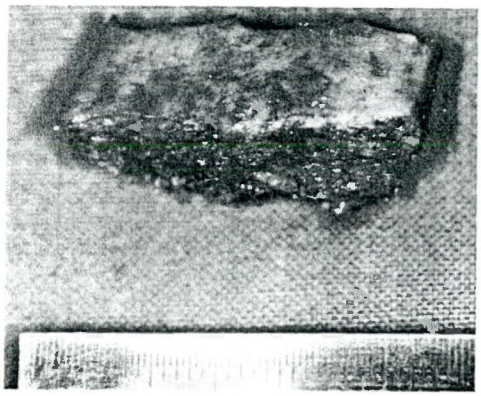


Figure 15–171. Iliac bone block with unilateral cortex used for the sinus inlay technique; the cortex can be placed cranially or vertically.

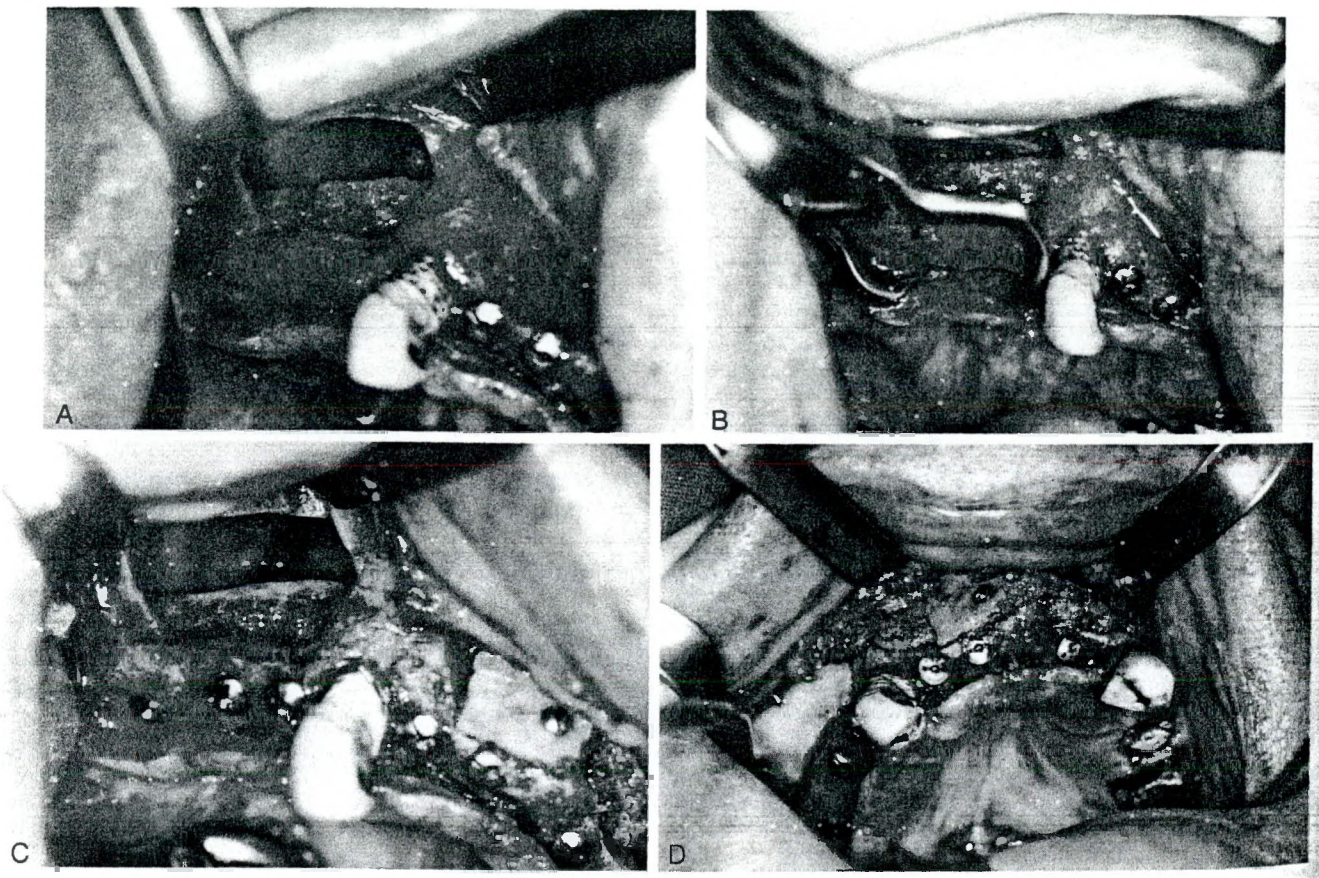


Figure 15–172. Intraoperative views showing the bone graft adapted to the sinus floor *(A)*, fixed by means of our specially designed fixation clamps *(B)*; insertion of three titanium screw implants *(C)*; replacement of the bony lid *(D)*. In the same case several other implants were inserted in the upper and lower jaws.

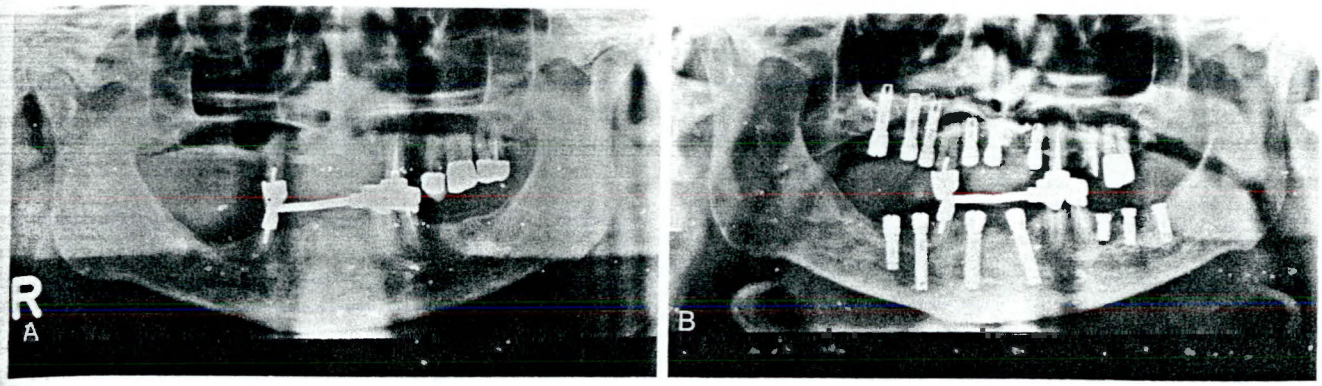


Figure 15–173. Orthopantomograms of the same case depicted in Figure 15–172, showing the edentulous free saddle on the right side of the maxilla with expansion of the maxillary sinus *(A)* and the postoperative condition after the abutment operation 6 months after insertion of the implants. *B*, Note the bone mass in the area of the former maxillary sinus with the incorporated implants.

Preliminary Results

The sinus floor inlay method with removal of the mucosal lining of this particular region was developed in 1987. Since then we have performed this procedure with or without Le Fort I operations on 68 occasions. Ninety titanium screws (Brånemark) have been placed in the sinus region, 3 of which were lost. In the piriform area 67 implants were placed, 6 of which were lost. No infections of the maxillary sinus have occurred.

Discussion

The removal of the mucosal lining is a very easy procedure and makes this method superior to the elevation of the sinus mucosa. On the contrary, even in skilled surgical hands, it is not surprising that the sinus membrane is often perforated when elevation is attempted, as the normal membrane is very delicate and the septa can impede elevation of the membrane as well. If the mucosal lining is incidentally perforated and graft material falls into the sinus, that is, is lying on the surface of the mucosal lining, an acute and chronic sinusitis may develop. This is not the case if a whole bone block is totally exposed to the maxillary sinus, as we know from thousands of cases of routine Le Fort I osteotomies in which bone grafts were interpositioned into the sinus walls. The only difference with our inlay method is that the bone graft is lying on the denuded floor of the sinus as illustrated for the downfracture of Method 1 (Fig. 15–174).

The use of autologous bone blocks also makes the simultaneous placement of titanium screw implants possible, in contrast to spongeous bone, and saves time in comparison with all methods of secondary insertion of implants after a healing period.

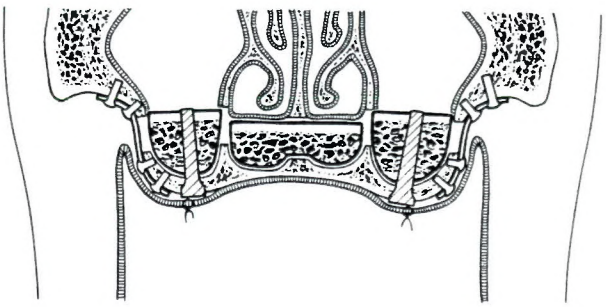


Figure 15–174. The bone blocks in correct position inlayed in the denuded antral floor as in the downfracture of Method 1. Also note that the bone blocks in the sinus can have any height desired, the height of the bone block in the piriform aperture should not much exceed the distance by which the maxilla was positioned downward in order not to compromise the nasal airways.

REFERENCES

1. Obwegeser H: Weitere Erfahrungen mit der aufbauenden Kammplastik. Schweiz Mschr Zahnheilk 77:1002–1012, 1967.
2. Bell WA, Buche WA, Kennedy JW, Ampil JP: Surgical correction of the atrophic alveolar ridge. Oral Surg 43:485–498, 1977.
3. Obwegeser H, Farmand M: Die Hufeisen-Sandwichosteotomie des zahnlosen Oberkiefers mit gleichzeitiger submuköser Vestibulumplastik. Schweiz Mschr Zahnmed 94:390, 1984.
4. Sailer HF: A new method of inserting endosseous implants in totally atrophic maxillae. J Craniomaxillofac Surg 17:299, 1989.
5. Sailer HF: Neue Methoden zur oralen Rehabilitation: Die Kombination präprothetisch-chirurgischer Operationen mit enossalen Schraubenimplantaten. Swiss Dent 12:23–36, 1991.

Osseous Reconstruction for the Edentulous Mandible

PART 1: RECONSTRUCTION OF THE PARTIALLY RESORBED ALVEOLAR PROCESS OF THE MANDIBLE

W. Howard Davis, D.D.S., David A. Hochwald, D.D.S., and Michael Marshall, D.D.S.

When evaluating the possibilities of placing implants in the completely edentulous mandible, one should be aware that contour can vary considerably from one area to another without being discernible in a panoramic or lateral cephalometric radiograph (see Chapters 5 and 14).

Because five implants in the dense anterior portion of the mandible usually suffice to provide a functional implant-supported denture, it is rarely necessary to consider placing screw/cylindrical implants posterior to the mental foramina in the edentulous mandible.

THE UNDERCUT OR KNIFE RIDGE

Immediately after the anterior teeth are removed, there may be significant thickness of bone of the crest for an implant, but a severe bony undercut may be present just below the crest of the ridge (Fig. 15–175). As resorption progresses, a knife-edge ridge (Fig.15–176)

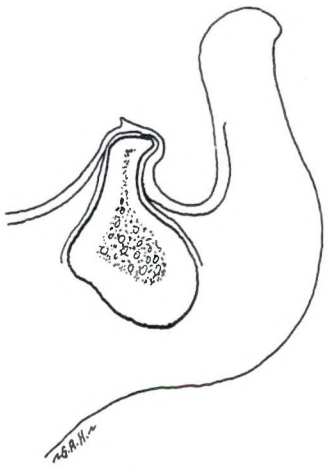


Figure 15–175. An undercut ridge that would often be present soon after extraction of the anterior teeth.

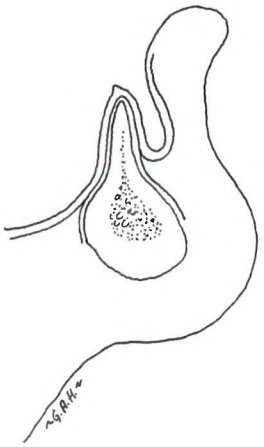


Figure 15–176. The common presentation of a knife-edge ridge.